USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY05 Final Performance Report (approx. May 05 – April 06)
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Cover Page

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Fiscal Year:	**2005**
FY05 ARS Agreement ID:	**59-0790-4-091**
Agreement Title:	**Breeding and Development of DNA Markers for Fusarium Head Blight Resistance in Wheat.**
FY05 ARS Award Amount:	**$ 185,912**

USWBSI Individual Project(s)

USWBSI Research Area*	Project Title	ARS Adjusted Award Amount
GIE	A Germplasm Center of Fusarium Head Blight Resistant Spring Wheat.	$ 67,317
VDUN	Breeding Fusarium Head Blight Resistant Spring Wheat.	$ 87,212
VDUN	Development of Spring Wheat Varieties with Fusarium Head Blight Resistance using DNA Markers and Retrospective Breeding	$ 31,383
	Total Award Amount	**$ 185,912**

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Principal Investigator Date

* BIO – Biotechnology
CBC – Chemical & Biological Control
EDM – Epidemiology & Disease Management
FSTU – Food Safety, Toxicology, & Utilization
GIE – Germplasm Introduction & Enhancement
VDUN – Variety Development & Uniform Nurseries

Project 1: *A Germplasm Center of Fusarium Head Blight Resistant Spring Wheat.*

1. What major problem or issue is being resolved and how are you resolving it?

The use of resistant cultivars will be one of the major components in managing Fusarium head blight (FHB) in wheat. The availability of diverse and well-characterized resistance sources is essential for success in developing and maintaining a high level of resistance in commercial cultivars. This project confronts the issues of finding additional or new sources of resistance in spring wheat, characterizing the resistance, and introgressing the resistance into elite germplasm. In the field season, a multiple nurseries system was used to handle materials at different stages of screening. The spring wheat germplasm from targeted regions are planted in non-replicated row plots and evaluated for scab reaction in Field selections are evaluated for reaction to point-inoculation in the greenhouse. Selections based on field and greenhouse screenings are planted in a replicated field Elite Germplasm Nursery for at least three consecutive years in different locations. Recombinant inbred lines of crosses of un-adapted resistance/Wheaton were advanced, selected and crossed with Wheaton.

2. List the most important accomplishment and its impact (how is it being used?). Complete all three sections (repeat sections for each major accomplishment):

Accomplishment: In 2005 field season, the FHB germplasm screening nursery was planted in St. Paul, Morris, and Crookston with St. Paul serving as the main location. The St. Paul nursery was inoculated with conidial suspension twice during the anthesis stage. The Morris and Crookston nurseries were inoculated with corn spawn. Sprinkler irrigation was used to provide favorable conditions for disease development. The St. Paul nursery consisted of about 700 plots, the Morris nursery had about 250 plots, and the Crookston nursery had 450 plots. In St. Paul, 140 accessions of spring wheat from the former Central Asia, Easter Europe were introduced into the PSN nursery. Based on the field disease severity, a total of 27 entries were selected as potential FHB resistance sources. These selections were increased in the greenhouse in fall 2005. The Elite germplsm nursery (EGN) consisted 182 accessions retained from 2002-2004 field selections. All the EGN entries were planted in St. Paul with 2 replicates. The 2002 field selections were also planted in Morris and Crookston with 2 reps/location. Thirty-two RIL lines of the Abura/Wheaton cross were planted over the three locations with 2 reps/location, 21 lines were selected for further FHB test and potential FHB resistance germplasm release. Identified resistance has been distributed to breeders upon request. To characterize the type II resistance, about 80 accessions from 2001 field selections were planted in the fall and spring greenhouses with 5 pots/accession/season. The plants were inoculated with single floret method. Most of the test lines are moderate to susceptible to point inoculation.

Due to the nature of multi-gene resistance and high degree of environment effect on FHB, we decided to use two cycles of RILs instead of a straight backcross method for introgression. Four RIL lines with good FHB resistance and acceptable agronomic traits from Aura/Wheaton cross were selected and crossed with Wheaton. In spring 2005 greenhouse, the F_2 seed was produced. Five FHB resistant germplasm lines PI 285933, PI

185380, PI 104131, PI 382167, and PI 350768 were crossed with Wheaton. The offspring were advanced three generations in the greenhouse by single seed descent. Wheaton/PI 81791 (type II resistance without 3BS QTL), and Wheaton/ PI 345731 (field resistance only) were advanced two generations to the $F_{5:6}$ generation with about 200 RILs in each cross. During this funding period, crosses between Abura/Tokai 66, ND 2710/Abura were advanced into $F_{5:6}$ RILs with about 100-150 lines/cross.

DNA of 148 accessions of final FHB resistance selections (1998-2001) were collected, and genotyped with SSR markers *xbarc 133*, *xgwm489*, *xgwm533*, *Qfhs.ndsu-3BS* for type II resistance.

Impact:

Sumai 3 type of resistance has been the main source of resistance to FHB. The discovery of new FHB resistance wheat germplasm is critical to enhance the level of FHB resistance and diversify the resistance gene pool. Our vigorous screening and proactive distribution of the newly identified FHB resistance germplasm will directly benefit the US wheat breeding programs for FHB resistance and diversifying the current gene pool. In the 2006 regional nursery for scab parents (URSN), six entries (five from South Dakota State University and one from North Dakota State University) had in their pedigrees germplsm discovered from this project.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?:

The identified and characterized resistance germplam will provide the wheat community diversified source of resistance for germplasm enhancement and fundamental studies of FHB resistance. The introgression effort will facilitate the breeding efforts to improve FHB resistance levels in commercial cultivars.

Project 2: *Breeding Fusarium Head Blight Resistant Spring Wheat.*

1. What major problem or issue is being resolved and how are you resolving it?

Wheat varieties with greater resistance to *Fusarium* head blight (FHB) would make a substantial contribution to reducing the losses from this devastating disease. Research in our program and other breeding programs has demonstrated that breeding progress toward resistance to this disease is possible with proper germplasm and screening procedures.

These objectives were:

1. Develop *Fusarium* head blight resistant wheat germplasm and varieties adapted for commercial production in Minnesota and the surrounding region and characterize the level of FHB resistance of all wheat varieties grown in the region.
2. Determine the effect of chromosome 5AS and 5BL FHB QTLs on grain yield and quality, resistance to other diseases, and other agronomic characteristics using near-isogenic line pairs.

2. List the most important accomplishment and its impact (how is it being used?). Complete all three sections (repeat sections for each major accomplishment):

Accomplishment: One experimental line, MN95229-A, was released as 'Ada' in January 2006. Seed of two additional lines, MN99436-6 and MN00261-4, were increased by Minnesota Crop Improvement Association in 2005. These lines have high grain yield, good grain quality, resistance to leaf rust and improved resistance to FHB. MN00261-4 has good tan spot resistance and appears to have FHB resistance comparable to Alsen.
Impact: Ada is competitive for yielding ability, especially in northern regions of the Red River Valley, has moderately strong straw, high test weight and protein, and resistance to leaf rust, tan spot, and preharvest sprouting. Ada has moderate resistance to FHB (better than the most popular variety in Minnesota, Oxen.
As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?: The most popular wheat variety in Minnesota in 2005 was Oxen. It is one of the more scab susceptible varieties available, but growers continue to favor it because of its grain yield. Ada has comparable grain yield, stronger straw, higher test weight and protein, much better leaf rust resistance, and improved FHB resistance.

Accomplishment: Five new experimental lines were entered in the 2005 Uniform Regional Scab Nursery. These lines were identified in previous testing as having improved levels of FHB resistance and were among the best performers in the nursery. A U of MN experimental line had the lowest DON and visual scabby kernel rating of the 43 entries (representing 8 breeding programs) in the 2005 nursery.
Impact: These lines combine FHB resistance from different sources and are candidates for germplasm release. These lines are available and have been requested by other wheat breeders in the region for use as crossing parents.
As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?: These materials contain unique combinations of FHB resistance genes and in many cases the

resistance levels are superior to the resistant checks used in the nursery. Increasingly, the other important characteristics desired of crossing parents are improving as well (e.g. shorter height, greater straw strength, better leaf rust resistance, better grain yield and quality).

Accomplishment: The FHB reaction of 23 spring wheat cultivars was assessed and reported to growers via print media and field day presentations.
Impact: FHB remains a potentially devastating disease in the region as severe damage was inflicted in 2005. Our FHB resistance ratings are an important part of growers' decision regarding which variety they will grow.
As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?: The U of MN FHB variety ratings are based on data from at least 6 FHB inoculated, mist-irrigated nurseries. In most cases, we have ratings of new varieties published by December of the year preceding the sale of certified seed to growers.

Accomplishment: During the 2005 growing season, *Fusarium* head blight-inoculated, misted replicated nurseries were established at Crookston, Morris, and St. Paul. A total of 4,550 rows were evaluated as part of this project. The FHB epidemic of 2005 allowed us to evaluate the reactions of varieties to this disease in naturally inoculated trials. This complimented our already extensive evaluations from inoculated nurseries.
Impact: Data from the last two years have indicated that U of MN releases and variety candidates have improved levels of FHB resistance. These include Oklee (2003) and experimental lines MN99436-6, MN00261-4, and MN01311-A. Our project continues to identify other lines with high levels of FHB resistance.
As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?:
Although the results of natural FHB epidemics must be interpreted with caution due to the confounding effects of heading date, it was clear from the 2005 data that our results from artificially inoculated trials agreed with results from the 2005 epidemic.

Accomplishment: Eight NIL pairs, differing for a FHB QTL on either chromosome 5AS or 5BL were evaluated for agronomic performance and disease reaction in 3 locations in 2005. No consistent effects on grain yield, protein, test weight, heading date, or height were noted. Three of eight pairs were significantly different in test weight and two pair were significantly different in height. The only significant correlation with FHB data was in one pair in which the taller NIL was more resistant.
Impact: Researchers will have a better idea of the possible negative characteristics associated with FHB QTL on chromosomes 5AS and 5BL.
As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?: This is the first report to our knowledge of possible pleiotropic effects of these FHB QTLs. The lack of consistent pleiotropic effects is good news for breeders wishing to pyramid FHB resistance genes.

Project 3: *Development of Spring Wheat Varieties with Fusarium Head Blight Resistance using DNA Markers and Retrospective Breeding*

1. What major problem or issue is being resolved and how are you resolving it?

Given i) the ongoing need for FHB resistant wheat varieties; ii) the current knowledge regarding the inheritance of FHB resistance and the number of quantitative trait loci (QTLs) that have been tagged with markers; and iii) the establishment of the USDA-ARS Small Grains Genotyping Centers, now is the time to employ our expertise and resources to address the objectives below:

1) Develop Fusarium head blight resistant wheat varieties adapted for commercial production in Minnesota and the surrounding region using DNA markers to enrich selected populations for their frequency of major FHB QTLs.
2) Characterize the relative FHB resistance of different combinations of FHB QTLs.

2. List the most important accomplishment and its impact (how is it being used?). Complete all three sections (repeat sections for each major accomplishment):

Accomplishment: As part of this project, 6,700 F_2 and F_3 plants were screened for 1-4 different loci using DNA markers. Markers for *Fhb1* (major QTL on chromosome 3BS) and another QTL on 5AS were included. A total of 14,112 datapoints were collected. The selected lines were planted in the field in 2006 for phenotypic selection.

Impact: The populations of F_2 and F_3 individuals screened with markers were selected based on previous observations that promising lines can be produced. These materials are now enriched for key genes and are likely to produce FHB resistant germplasm in the future that can be used as crossing parents or possibly varieties

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?: This was a pilot project to serve as an example for how other breeding projects can benefit from interaction with the Genotyping Centers. This project utilized retrospective breeding and judiciously applied marker-assisted selection on populations with a proven high probability of producing variety candidates. By applying marker-assisted selection in the most promising populations, we hope to demonstrate that this technology can increase the rate and frequency of variety candidates with high levels of FHB resistance and serve as an example for how other breeders may address complexly inherited traits, including FHB resistance, with marker technology.

Include below a list of the publications, presentations, peer-reviewed articles, and non-peer reviewed articles written about your work that resulted from all of the projects included in the grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.

Peer-reviewed Articles:

Liu, S., X. Zhang, M.O. Pumphrey, R.W. Stack, B.S. Gill, and J.A. Anderson. 2006. Complex microcolinearity among wheat, rice and barley revealed by fine mapping of the genomic region harboring a major QTL for resistance to Fusarium head blight in wheat. Functional and Integrative Genomics 6:83 -89.

Anderson, J.A., R.H. Busch, D.V. McVey, J.A. Kolmer, Y. Jin, G.L. Linkert, J.V. Wiersma, R. Dill-Macky, J.J. Wiersma, and G.A. Hareland. 2006. Registration of 'Ulen' wheat. Crop Sci. 46:979-980.

Abstracts:

Liu, S. , M.O. Pumphrey, X. Zhang, B.S. Gill, R.W. Stack, J.S. Gill, J. Dolezel, B. Chalhoub, and J.A Anderson. 2005. Toward Positional Cloning of *Qfhs.ndsu-3BS*, a major QTL for Fusarium head blight resistance in wheat. *In* Plant & Animal Genome XIII Abstracts, San Diego, CA.

Zhang, X., J. Anderson, and Y. Jin. 2005. Inheritance of Fusarium head blight resistance in Abura. Phytopathol. 95:S49.

Anderson, J. 2005. Enhancing Fusarium head blight resistance in wheat using breeding and DNA markers. Phytopathol. 95:S124.

Anderson, J., S. Liu, X. Zhang, Y. Jin, R. Dill-Macky, and S. Chao. 2006. Marker-assisted selection for FHB resistance in wheat. *In* CIMMYT Fusarium head blight workshop on the global Fusarium initiative for international collaboration, El Batan, Mexico.

Reports:

Anderson, J., J. Wiersma, J. Kolmer, and R. Dill-Macky. 2005. Spring Wheat. *In* Preliminary Report 24; 2005 Wheat, Barley and Oat Variety Performance in Minnesota, Preliminary Report, Edited by Jochum Wiersma.

Anderson, J.A., G.L. Linkert, and J.J. Wiersma. 2005. Hard Red Spring Wheat. *In* Minnesota Varietal Trials Results, University of Minnesota Extension Service.